Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

THE

AMERICAN NATURALIST.

VOL. XVI. — *JUNE*, 1882. — No. 6.

TRANSFORMATIONS OF PLANORBIS AT STEINHEIM, WITH REMARKS ON THE EFFECTS OF GRAVITY UPON THE FORMS OF SHELLS AND ANIMALS.[1]

BY ALPHEUS HYATT.

IN continuation of our review in this journal for October last (p. 793) of Professor Hyatt's contribution to the evolution theory, we make the following extracts from his last condensed paper, and reproduce from the Proceedings of the American Association the plates illustrating the paper. The results of his studies on the Steinheim shells are roughly exhibited on Plate VI, and may be described briefly as follows. Figs. 1, 8, 12 and 16, are the ancestors, varieties of *Planorbis levis* from the older Tertiaries of another locality, identified, named, and kindly sent to me with eleven other specimens of this species by Professor G. Sandberger,[2] who opposes the evolutionary conclusions of both Hilgendorf and myself.

From these four varieties spring four distinct lines of descent. Fig. 1 begins the series from 2-7, in which of course numbers of the connecting forms are not figured. Fig. 8 begins the series from 9-11, much shorter and containing fewer forms than in series 2-7. Fig. 12 also gives rise to a short series with only few forms. Fig. 16, however, is the starting point for a compound series, or one composed of at least three sub-series, 19-20, 21-24, and 25-28.

The intermediate forms by which the gap between the four ancestors and the four first forms of each series, viz: 2 and 9 and 17, which occur in the Steinheim basin, is very complete, but neccessarily left out in this plate.

---

[1] From the Proceedings of the American Association for the Advancement of Science, Vol. XXIX, Boston Meeting, August, 1880.

[2] The author of the most complete Memoir on Tertiary shells in existence, Conchylien d. Vorwelt.

Numbering the series from right to left we see that Series I has three sub-series. Two of these show a tendency to uncoil, to become distorted and smaller than the ancestor, Fig. 16, while the third decreases in size, but has a form, Fig. 20, which is turreted like Figs. 11 and 6.

Series II maintains a size about the same throughout, but becomes flatter than the originating form, Fig. 12. Series III grows sensibly larger, and 10–11 are turreted-shells with a more rigid and sub-angular form of whorl than the primal form of Fig. 8.

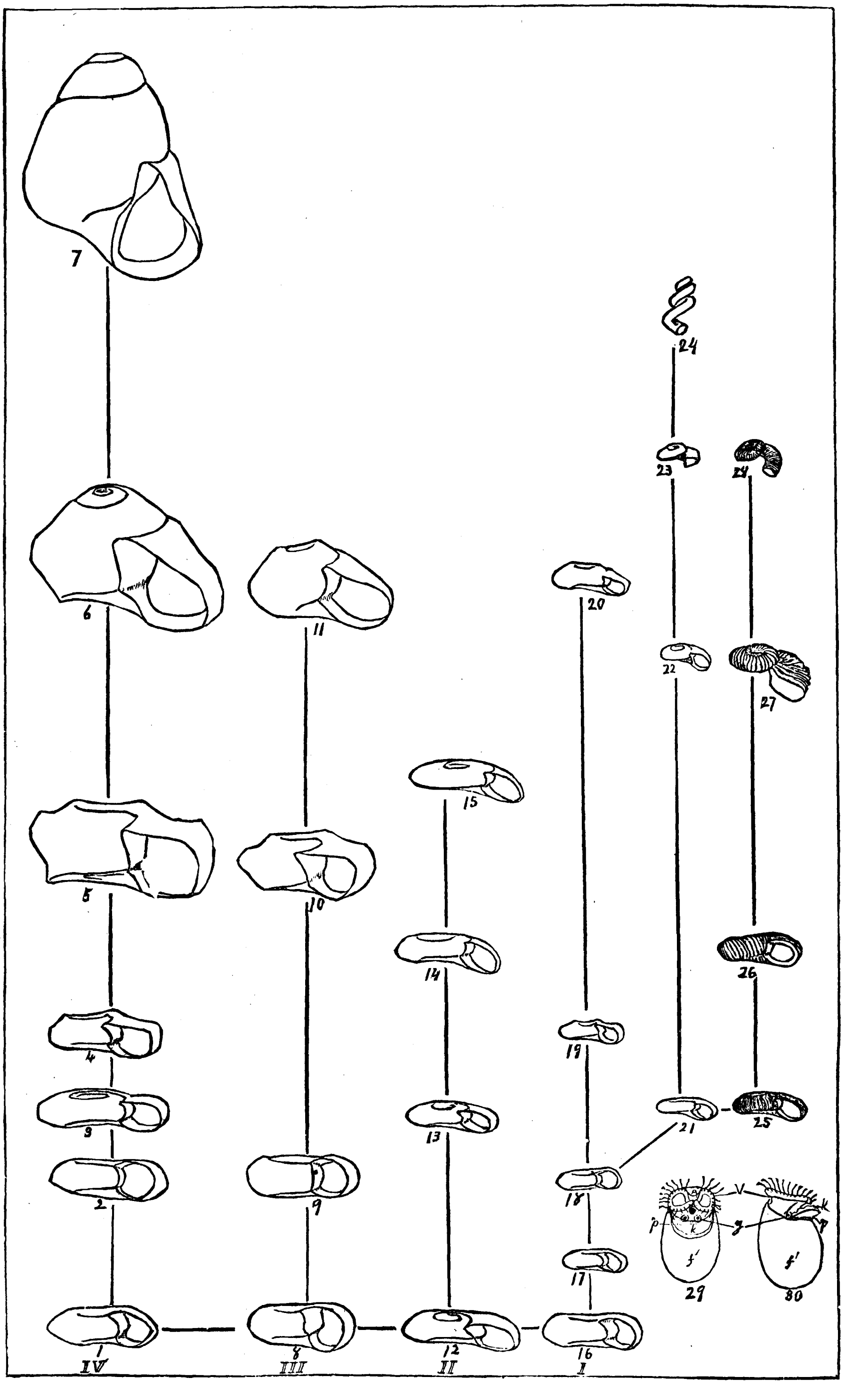
Series IV exhibits not only greater increase in size, but vastly greater differences in form and in other characteristics of the shell from Fig, 1, with which it started.

We can, therefore, without fear of error call series IV a highly progressive series; Series II a persistent series; sub-series 3 of Series I a partly retrogressive series; sub-series 2 of Series I, a purely retrogressive, and sub-series 1 of Series I also partly retrogressive; since, though it decreases in size and becomes deformed and uncoiled, it also has a tendency to produce a new characteristic, the transverse ribs, and also increases in size its more closely coiled forms, as in Fig. 26.

There is also other testimony going to show that this classification is correct. Semper's researches on *Lymnæus stagnalis* show, that under the most favorable physical conditions, this species increases to a maximum of size and has larger whorls, while under less favorable conditions with relation to food and temperature, the size is very much decreased.

The immediate results of weakness, produced by wounds, are also important in this connection. Pl. VII, Figs. 21, 21*a* and 22, a diseased *Pl. oxystomus*, var. *revertens* Hilg, is a diseased specimen of the same species as Fig. 9, Pl. VI. Compare this diseased, partly uncoiled, shell with the species, Fig 23, Pl. VI, *Pl. denudatus* and *minutus*. The weakness consequent upon old age is equally significant and has a similar meaning. Pl. VII, Fig. 22, represents the effect of old age in distorting the growth of the outer whorl of *Pl. oxystomus*. Compare with Fig. 22, Pl. VI. These are true cases of disease of comparatively rare occurrence in *Pl. oxystomus*. I have in my collection many similar

PLATE VI.



Transformations of Planorbis at Steinheim.

cases and have lately found some diseased shells of *Pl. trochiformis*, Fig. 7, Pl. VI. These are dwarfed, and show a tendency to unwind the spiral; so that they look remotely like the beginning of a series of transition forms from *Pl. trochiformis* to *Pl. denudatus*, Fig. 24, Pl. VI.

The following extracts contain the author's conclusions on the influence of the environment on mollusks:

Darwinists would say that want of bilateral symmetry or the unsymmetrical spire was of advantage to the animal, therefore it was selected and perpetuated.

Now this statement may be readily accepted, with the understanding that the "therefore" does not imply a relation of causation.

Most of the characteristics caused by the physical surroundings are of course advantageous, but the physical forces are the causes and not the advantageous or disadvantageous nature of the characteristic.

The form of the embryonal shell is straight, bag like or swollen, tubular; Figs. 29–30, Pl. VI.

The simplest form of all is a disk with which this embryonal bag begins, but this or the embryonal shell is not necessary for us to consider.

The coiled unsymmetrical shell (*ba*) is carried above the foot (*k*) as in the *Helix pomatia*, Fig. 8, Pl. VII, and Planorbis, Fig. 8 *a* Pl. VII. This is built by the mantle or internal soft covering of the body *d*, Fig. 9. The shell has been removed, and the fleshy cone of the mantle containing the stomach, intestines, etc., has been partly unrolled to show that it was originally coiled up inside the shell. The structure of the shell can be more easily understood in forms like Figs. 11, 12, Pl. VII, where the mantle is not so long and not coiled, but builds a broad, evenly balanced, conical roof above the foot as in the Patella or Limpet. If this shell be divided into halves and one half removed as in Fig. 12, the structure of the shell becomes visible and also the relations of the mantle *d*, and the mantle border *d'*, to each other and to the two layers of the shell, *e*, and *e'*.

This animal was once small enough to occupy only the upper part of this cone and then as it grew in size built the shell above itself. The outer layers, *e*, Fig. 12, the outer edges of which are seen also on the surface of the shell, *ba*, Fig. 11, were plastered up, one inside of the other, by the mantle border, *d*+, which exactly fits the last one formed, and the inner, longer layers *e'* which simply serve to strengthen and support these are laid on by the mantle itself, *d*, Fig. 12.

The mantle border in the gasteropod forms a sort of collar, *d*+ Figs. 8 and 12, Pl. VII, around the edge of the mantle, through which the creeping disk or foot projects when the animal is expanded. The mantle border among the lamellibranchs *d*+Fig. 18, Pl. VII,[1] forms a wider opening, or slit fore and aft, but it serves the same purpose of an aperture for the protrusion of the foot, when this is used as an external organ of motion, Fig. 18, Pl. VII.

Any force which, would confine or interfere with the excreting surfaces of the mantle border, would affect the form of the imbricated layers *e'* which determine the shape of the shell, and thus change or curve the form of the cone. The weight of the shell itself or gravitation is such a force. If we try to account for the regularity of the spirals, whether bilateral or unsymmetrical, we are struck by the fact of their great regularity of curvature, and that this regularity can only be accounted for as the result of some general and constantly acting physical force, which tends to make the bag-like, straight shell of the young bend first into a bilateral spiral and then into an unsymmetrical spiral.

The force of gravitation, unless counteracted by great muscular strength, or the equilibrium of a perfectly cone-shaped, erect shell, as in some mollusks, would make the growing shell hang back and weigh upon the hinder portion of the border of the mantle, thus compressing the excreting surface in that quarter and decreasing the breadth of the shell layers built by this part.

This would make the shell assume the form of a bent cone or the bilateral spiral as in Figs. 24–25, Pl. VII.

The unsymmetrical spiral would be occasioned by any additional inequality in the weight of one side over the other, which could be occasioned by the distribution of the heavier internal organs, particularly of the stomach, ovaries, etc. Any irregularities of weight on one side more than the other would, it is obvious, also compress that side as well as the back part of the mantle border, and tend to narrow the deposits.

This would occasion a deflection laterally, and we should have what is so commonly the case, a shell bilateral in the young or at the apex becoming by growth unsymmetrical or spiral.

---

[1] See also Fig. 3, a fresh water clam (Anodonta) thrown widely open.

This explanation is obviously applicable to the regular spirals, but the test cases are the irregular spirals.

These occur through weakness occasioned by wounds, disease, Fig. 21, Pl. VII, or old age, as in Fig. 22, Pl. VII.

All of the distortions thus produced tend to be irregular, that is the animal becomes too weak to counteract the effects of the weight of the shell by its inherited muscular power, and it falls over more or less to one side destroying the regular curve of the spiral. This falling over to the side of greatest weight occasions an irregularity in the deposition of the outer shell layers, and the shell becomes more and more irregular as the animal grows weaker in old age or through disease.

Another proof of the effects of gravity lies in the fact, that the irregularity of form of the shell is proportional to the extent to which it is supported and the excreting border of the mantle relieved from the effects of its weight.

Thus, a perfectly regular spire in the young, by being supported, is turned into an irregular meandering tube in the after growth of the same animal.

Magilus antiquus crawls freely when young among corals, and has, during this period, a regular turreted shell, Fig. 23 *ba*, Pl. VII. It becomes finally fixed in the growing coral, which completely invests and supports it, and thereafter its shell is a rough irregular tube growing upwards in the direction of least resistance. The border of the mantle being free from compression on all sides, deposits shell matter about equally all around in the specimen figured, and therefore grows upward in a straight line.

The Vermetidæ are supported in various degrees in the adults but free in the young. Their shells, therefore, though having a regular spiral in the young, are in proportion to the support received, transformed into tubes more or less meandering after they become attached as in Fig. 10 *a*, Pl. VII, or loose irregular spirals rising up like corkscrews and only supported on one side as in Fig. 10.

The Ammonoids and Nautiloids are notable for the complete bilateral symmetry of their spiral shells.

Diseased specimens, which are not infrequent, however, tend to become unsymmetrical, coiling like the Gasteropods, as is well known to all experienced palæontologists. These are commonly spoken of by Quenstedt and others as diseased or deformed or sick species.

Once at the Sorbonne in Paris, Professor Hèbert, a distinguished French palæontologist, showed me a magnificent series of uncoiled Cretaceous Ammonites, and by way of testing these conclusions, I asked this question:

"Where, M. Hèbert, is the closely coiled symmetrical form which ought to be found with these?" He turned to the other side of the room, and pointed out the required form, saying, "There it is, I found it last summer."

These and other facts of a similar kind indicate that when physical surroundings become unfavorable to any organization, it takes on a certain series of retrograde transformations.

When they occur in the individual in the decline of life, or prematurely in the course of growth, through disease, they are similar to the characteristics of whole species, and even groups of degenerate forms. As in the case described above, Fig. 22, Pl. VII, is taken from an aged specimen, but it is distorted in the same way as the diseased specimen, Fig. 21, Pl. VII, and the retrogressive or degraded species of Series I, Pl. VI.

All the facts corroborating this assertion have already been published and are too numerous to be described in the limits of a paper like this.

The direction of the spiral is backwards or away from the mouth in the Gasteropods and towards the mouth in the Lamellibranchs; in, both, however, it is in the direction in which gravitation acts with greatest effect.

The Lamellibranchs have a split shell, with two valves. Each valve is unsymmetrically spiral, but there is one on each side of the vertical axis or *axis of gravity*, so that they balance each other and together form a bilaterally symmetrical shell, Figs. 15, 18, seen from the side, and 16, 17, from behind; *a*, spiral of right valve, and *b*, spiral of left valve.

The spiral and the outlines of the valves are equal on either side except in those forms which change the vertical axis and lie habitually on one side.

These are deformed and unequal; the deformation is in accordance with the amount of support and the resistance of the surroundings.

Thus oysters may grow to the right or left or very irregularly, fitting the curvature of surface, Fig. 13, Pl. VII. In the young they are free moving, bilaterally symmetrical, and for a time attached by a byssus, and then lie over on one side.

Their symmetry is precisely accordant with these changes ending with having the lower valve permanently attached and larger and more concave than the upper.

Fig. 14, Pl. VII, shows the outlines of a clam shell above that of an oyster shell, and both in their real positions for comparison with each other, the beaks of the clam shell being upon the back and those of the oyster shell across the anterior or mouth end of the animal which has built the shell. The positions of the mouth in each animal are shown at *l*, *l*.

Fig. 18, Pl. VII, shows one side of a clam supposed to be buried in the mud with the siphons extended to the surface and the mantle border or shell-building organ *d* +, and the digging foot *k*, in their natural expanded condition.

What are the changes which can take place in a member of the oyster family by change of habit?[1] Can an animal of this family, which is always unsymmetrical when lying on one side, have a different position and thus return to the normal condition and have valves which are symmetrical and bilateral?

This question is answered by Lima, one of the same group as the oyster, a free swimmer but also burrowing into sponges as the clam does into the earth. This change of habit produces a corresponding change in symmetry, and it becomes like the clam, also perfectly bilateral, Fig. 16, Pl. VII.

On the other hand, can one of the fresh-water clams, Fig. 3, 17, Pl. VII, which are the reverse of the Ostreadæ, being almost invariably free moving or burrowing, and habitually bilateral, become attached, and if so does its shell become distorted like that of an oyster?

The answer to this is Mulleria and genus Ægeria. Mulleria, Fig. 19, becomes attached and is distorted so as to resemble the oyster and not only that, but the animal changes, since there is but one large muscle *g*, as in the oyster, Fig. 1, Pl. VII, in place of the two muscles used to close the shell in the clams, *g*,*g*, Fig. 18, Pl. VII, and the beaks of the shell have shifted from the middle of the back to the anterior end. Probably all attached animals show this tendency. Their attached and supported parts, the bases of the stems, etc., are irregular in form and growth, and their free upper parts more or less laterally symmetrical. The radiate symmetry of the soft bodies of corals and of the harder, plate-covered cups of the Crinoids, the attached parts of the Ascidians as compared with their freer bodies above; the perfect bilateral symmetry of the free moving parts of the Mollusca, as in the Helix, Fig. 8, Pl. VII, and Planorbis, Fig. 8 *a*, as compared with their supported spiral shells, the same perfection in the free Eolis, Fig. 2, Pl. VII, which has no shell in the adult, and in most of the Pteropods, Fig. 7, Pl. VII, free swimming animals, as well as in the Cephalopods, Fig. 5, Pl. VII.

---

[1] The effects of change of habit have lately been followed out by Dr. Anton Dohrn in an essay in which he shows the results of change of function induced by new conditions to be the transformations of the organs themselves. His hypothesis states that new habits bring about or induce the organs to exercise apparently new functions, which were latent or only partly developed under the original conditions of the surroundings. See Der Ursprung und d. Princip des Functionswechsel, by Dr. Anton Dohrn, Leipzig, 1875.

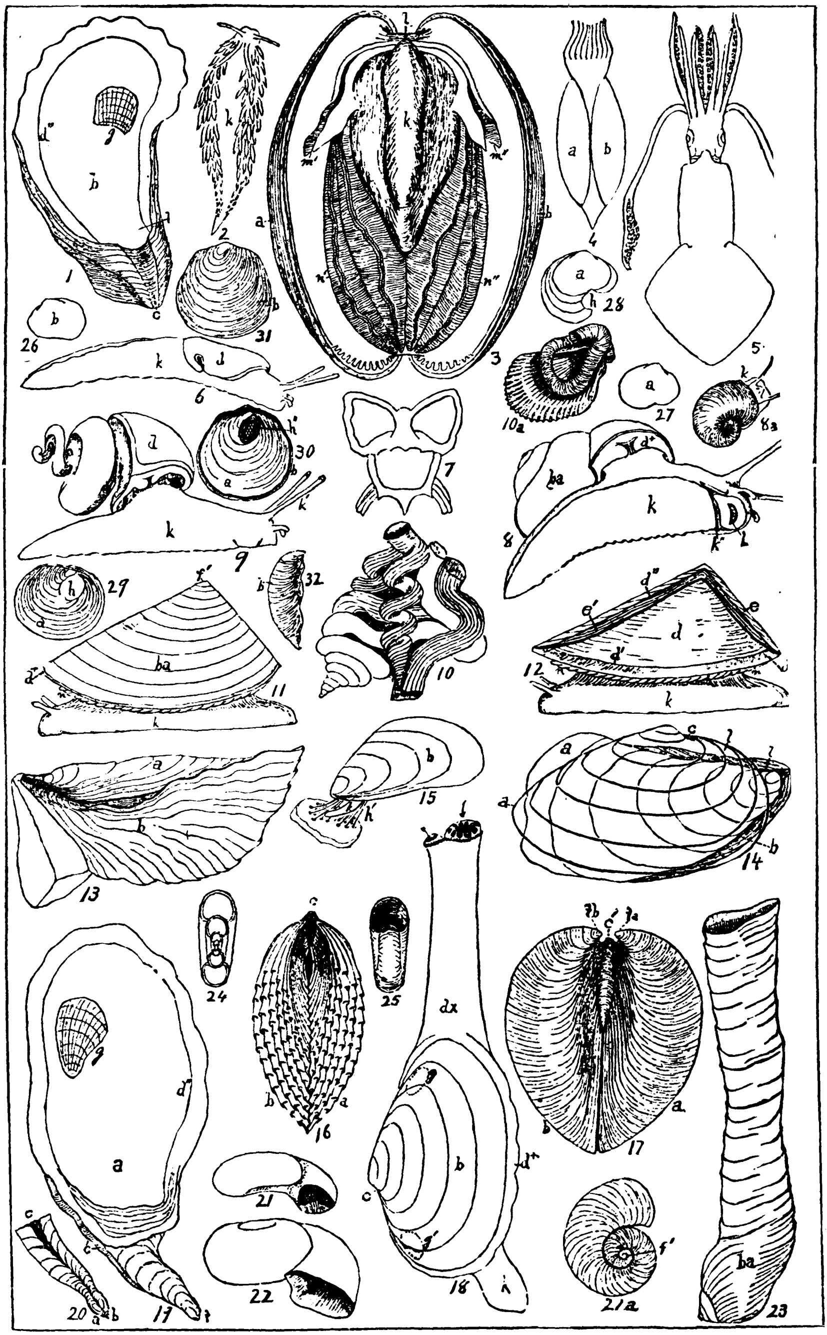
One of the best proofs of this position lies where it is least to be expected. The Brachiopoda are attached by a peduncle, or fleshy stem, and the upper valve, and not the lower, is the larger, just the reverse of the oyster.

Upon examination, however, it is found that it is the upper valve which is held by the peduncle and the lower valve alone opens and closes. Then again Lingula, another type of Brachiopod, which is not fixed by its peduncle, but simply occupies a sand burrow, and can move its valves sidewise, one over the other, has equal valves. Professor E. S. Morse's investigations have shown that the symmetry in these animals changes from a worm-like upright form of three rings or segments, and becomes laterally symmetrical by subsequent changes in the form of the first and second segments, the third changing into the peduncle. Here then a round worm-like form exchanges its cylindrical shape for a flatter, shell-covered body in two of its segments, which become bent over into a horizontal position, while the third, which remains vertical, retains the original round tubular form.

The Anomia, Figs. 31, 32, Pl. VII, presents a series of changes very similar in their meaning, though this animal is closely allied to the oyster.

It has the lower valve flat, resting upon and taking the form of the surface upon which it grows. The upper valve, *b*, Figs. 30–31, is convex and larger than the lower concave valve, *a*, Fig. 30, and is supported by a plug, *h''*, passing through the lower valve.

PLATE VII.



EXAMPLES OF EFFECTS OF PHYSICAL SURROUNDINGS ON MOLLUSKS.

In this case in which also the upper valve is the larger, it is this which receives the direct support of the attached plug.

The young are at first free, then attached by a byssus. Figs. 26, 27, show the right and left valves at an age when the animal has fallen over on the right side, and the notch, Fig. 27, begins to be formed.

Fig. 28 shows how the lower valve continues to build out around the notch towards the anterior end, and in Figs. 29 and 30, it becomes complete. This greater demand upon functional activity of the lower side of the mantle, and the fact that this is the movable valve, explains why it is not larger than the upper valve as in the oyster.

As was pointed out to me by Mr. J. S. Kingsley, the growth of the upper and lower valves sidewise is really an effort on the part of the animal to recover, by lateral growth in a new direction, the symmetry lost when it fell over on its side. Any one comparing Figs. 28 and 31–30 will see that the long axis of the form in Fig. 31 is at right angles to what it is in Fig. 27.

I shall call this tendency, to equalize the form in the direction of a horizontal plane, *geomalic;* the downward tendency of the growth being designated by botanists, *geotropic.*

The Anomia, when it falls over, loses its bilateral symmetry, because the right and left sides become upper and lower, and being in the vertical position, they are unequally affected by gravity and by change of function. At the same time the dorsal and ventral sides, which were before vertical, have become horizontal; and the geomalic growth of the ventral side, in order to restore the lost equilibrium in a horizontal direction, at once begins. This does not attain perfect lateral symmetry. The form of the animal cannot be easily changed, and the dorsal and ventral sides are still distinguishable; therefore, it is necessary to call this tendency of the growth by a new name, so that we can speak of the dorsal and ventral as well as the right and left sides as having the same tendency to assume by geomalic growth the natural and inevitable condition of equilibrium. The experienced observer will at once think of many apparent violations of this law.

Many larval forms of Gasteropods begin to build the spiral, while they are still within the egg, or still free swimming animals.

Balfour[1] states, in his masterly summary of Comparative Embryology that, during an early larval period, "in most Gasteropods, the shell and mantle extend much more to the left than towards the right side and that the commencement of the spiral shell is thus produced." This same explanation applies to the falling over on one side of the young Anomia and oyster, in so far as the side upon which they fall is heavier than the other or upper side.

---

[1] Comparative Embryology, vol. 1, p. 190.

These seem to be readily accounted for as the direct results of hereditary peculiarities which have arisen in their ancestors and become embryonic through the action of the law of quicker development or acceleration explained above, and into the same category comes also the straight anomalous bag-like shell or plate of the embryo, and the split bivalve shell of the young oyster, which according to Professor Brooks is never an embryonic plate as in other Lamellibranchs.

The problem has not been approached among animals as it has among the plants by Sachs, Darwin and others. and we do not know how to distinguish between the direct effects of gravitation upon the growth of any animal at any one stated period of its life, and the effects of the proximate causes arising from the inherent tendencies of heredity.

Notwithstanding these imperfections in the evidence, and the absence of experimental proof, it has appeared to me that the discussion of this question would not be without usefulness in calling attention to what seems to me one of the most fruitful lines for experimental research. This, though now attracting much interest among botanists, on account of Sachs' experiments and Darwin's last book, is neglected by zoölogists.

In conclusion, Hyatt summarizes what he has endeavored to condense in his brief communication.

I have tried to show the results of the study of the history of a single species, *Planorbis levis*, and its evolution into many distinguishable forms, of which 14–19 may with justice be called by different names and considered as distinct species. I have also striven to bring into comprehensible shape the following conceptions:

First, that the unsymmetrical spiral forms of the shells of these, and of all the mollusca, probably resulted from the modification of the action of the laws of heredity, produced by gravitation.

Second, that there are many characteristics in these and in other groups of shells which are due solely to the uniform action of the physical influence of the immediate surroundings, varying with every change of locality, but constant and uniform within each locality.

Third, that the Darwinian law of natural selection does not explain these relations, but applies only to the first stages in the establishment of the differences between forms or species in the same locality. That its office is to fix these in the organization and bring them within the reach of the laws of heredity.

Fourth, that after this is done, they are inherited according to the law of heredity with acceleration, which shows us in what manner these differences and all other inheritable characters, however originated, may with greater or less rapidity, become incorporated in the young of descendant forms and species.

Fifth,[1] that in these earlier stages they are more or less protected from change and may therefore remain comparatively invariable through long periods of time, or may be exposed to great changes in exceptional cases, and modified accordingly.

Sixth, that these phenomena show, that in growth, reproduction and heredity by acceleration, there is manifested a decided reaction of the organism, which succeeds in building up and maintaining the type structure and form, under all ordinary or normal terrestrial conditions, but in some cases fails in fully accomplishing this when exposed to exceptional surroundings, as in some cases of parasitism.

Seventh, that gravity appears to be one of the causes of the differences in effort, function and anatomy observed between the sides or ends of animal forms when in vertical relations to each other and to the earth, whether these be the anterior and posterior ends of the form, or the dorsal and ventral, or the left and right sides.

Eighth, that the bilateral or geomalic growth observed in the internal organs and the external parts of the organism when their sides are in their original and hereditary positions, and the geomalic growth of the dorsal and ventral sides, when these become horizontal through change of habit, appear to be directly or indirectly, responses to the demands of gravity.

Ninth, the origin of the limbs, etc., in pairs, while mere buds, is difficult to account for, if they are not considered as the results of the efforts of the tissues of animals to maintain the equipoise of all the parts by geomalic growth in obedience to the laws of gravity.

---

[1] The fifth and sixth propositions are not discussed in this communication for want of space, but were given in the Memoir on Steinheim Shells above quoted, and in the evening lecture of which this is an abstract.

EXPLANATION OF LETTERS.

a, right valve; *b*, left valve; *ba*, shell; *c*, hinge area; *c'*, hinge ligament; *d*, mantle; *d*+ mantle border; *d'*, inner limit of mantle border; *d''*, pallial line or trace made by *d'* on the inner side of the valves; *dx*, siphon of double funnel of clam; *e*, outer layers of shell built by the mantle border; *e'*, inner layers of shell built by the mantle itself; *f*, beaks of young valves, still remaining to form the beaks of the two valves; *fa*, right beak; *fb*, left beak; *f'*, beak, apex or young shell of Gasteropod still remaining at the center of the spire in Gasteropods; *g*, impression or mark made by the posterior adductor muscle on the interior of the valves; *g'*, position of anterior adductor muscle shown through the shell only by a dotted line; *h*, depression or hole made by the byssus or byssal plug in the lower valve of Anomia; *h'*, byssus of threads; *h''*, byssal plug; *k*, foot or crawling disk; *k'*, tentacles or feelers; *k''*, division between foot and head; *l*, position of the mouth; *m*, palpi, or flaps for conveying the food into the mouth; *m'*, right pair; *m''*, left pair; *n*, gills; *n'*, right pair; *n''*, left pair.

PLATE VI.

The specimens from Undorf all belong to an older Tertiary period than that at Steinheim. Plate VI is copied from Pl. 9 of memoir above quoted, except Figs. 29–30.

SERIES IV.

Fig. 1, Pl. levis, Undorf.
" 2, " Steinheimensis, Steinheim.
tenuis,
" 3, " Steinheimensis, }[1] "
" 4, " tenuis, "
" 5, " discoideus "
trochiformis,
" 6, " discoideus, } "
" 7, " trochiformis, "

SERIES III.

" 8, " levis, Undorf.
" 9, " oxystomus, Steinheim.
" 10, " supremus, "
" 11, " " var. turrita, "

SERIES II.

" 12, " levis, Undorf.
crescens,
" 13, " parvus, } Steinheim.
" 14, " crescens, "
" 15, " " "

SERIES I.

Sub-series 3.

" 16, Pl. levis, Undorf.
minutus,
" 17, " levis, } Steinheim.
" 18, " minutus, "
" 19, " triquetrus, "
" 20, " " "

Sub-series 2.

" 21, " minutus, Steinheim.
denudatus,
" 22, " minutus, } "
denudatus,
" 23, " minutus, } "
denudatus,
" 24, " var. distortus, } "

---

[1] Names written in this way indicate the transition forms, as in this case the variety connecting Steinheimensis with *tenuis*.

Sub-series I.

FIG. 25, " costatus, minutus, } Steinheim.
" 26, " costatus, "
" 27, " costatus, var— "
" 28, " costatus, var— "
" 29, Doto coronata? young showing the oval shell and the swimming organ or velum from above. *V*, velum, *y*, eyes, *p*, operculum, the hinged disk used in closing the opening of the shell when the velum and foot, *k*, are drawn into it as the animal retracts. The mouth is indicated by the black spot near the center of the velum.
" 30, View of the same taken partly from the side.

PLATE VII.

FIG. 1, Left or lower valve of oyster (Fig. 13 *b*).
" 2, Eolis seen from above (after Adams).
" 3, Anodonta with shell open.
" 4, Young of oyster (after Brooks), abdominal view.
" 5, Loligo pallida (after Verrill), dorsal view.
" 6, Limax, side view.
" 7, Cavolina, dorsal view (after Brown).
" 8, Helix, seen partly from the under side.
" 9, The same with the shell dissolved by acid, showing the conical bag of the mantle partly unwound.
" 10, Vermetus tricarinatus, group of.
" 10*a*, " a broken specimen winding about on a shell of Lima.
" 11, Patella, diagram showing relation of shell to the crawling disk.
" 12, Same, edge of shell in section, and mantle exposed on one side.
" 13, Oyster in natural position attached firmly to a stone, but projecting without other support for about ¾ of its own length.
" 14, Clam shell (Mya) in outline above an oyster shell and both in the same position with reference to the structure of the two animals, if these were in their places inside of the shell.
" 15, Mytilus edulis (after Morse), common mussel attached to a stone by its byssus with the foot protruded.
" 16, Lima, view from the posterior end, showing bilateral symmetry.
" 17, Anodonta, same.
" 18, Mya arenaria. Common clam seen from the side with the siphon and mantle-rim or foot extended.
" 19, Mulleria, right or attached valve, with the solidified beak and the young shell showing at the end of the beak (after Adams).
" 20, Beak of the same showing the form of the young shells, from the dorsal side.
" 21, Pl. oxystomus, var. revertens, spiral showing the unwinding in an adult individual, due to disease.
" 21*a*. Top view of Fig. 21, and showing also the nucleus or young shell.
" 22, Pl. oxystomus, extremely old specimen showing similar unwinding of the spiral due to the weakness of senility.
" 23, Magilus antiquus, showing the regular spiral below and the irregular straight shell above built after the spiral shell has been buried in the coral (after Woodward).
" 24, Pl. steinheimensis, var. æquiumbilicatus, view of section showing how perfectly balanced the two sides of the spire are in some shells during their entire growth.
" 25, External view of the same shell, seen from the ventral side.
" 26, Anomia, young shell, left valve (after Morse).
" 27, Anomia, young shell, right valve (after Morse).
" 28, Anomia, young shell, right valve after the shell is turned so as to rest on this valve, which is now below and is making an effort to readjust the lateral symmetry by the geomalic growth of this valve around the byssal plug (aftor Morse).
" 29, The same, with the same valve after it has been built around the byssal plug (after Morse).
" 30, Anomia glabra, a full-grown shell, seen from the lower, right side, with upper left valve showing its projecting edges and beak beyond.
" 31, The same from the upper or left side, lower shell necessarily concealed.
" 32, The same from the anterior end to show distortion produced by the change in position. The lower or right valve is too concave to be visible.

[All figures not otherwise designated are original.]